N-63-4-3

TAC-TR-61-15

OPERATIONAL TEST AND EVALUATION

NOISE SUPPRESSOR SYSTEM TYPE A/S32A-5

JUNE 1963

HEADQUARTERS
TACTICAL AIR COMMAND
United States Air Force
Langley Air Force Base, Virginia

TAC-TR-61-15
June 1963

Operational Test and Evaluation
Noise Suppressor System
Type A/S32A-5

Publications Review

This report has been reviewed and is approved.

William A. Adams
for J. H. MOORE Col USAF
Major General, USAF
Deputy for Operations

HEADQUARTERS
TACTICAL AIR COMMAND
United States Air Force
Langley Air Force Base, Virginia

FOREWORD

The authority for TAC Test 61-15, Noise Suppressor System Type A/S32A-5, is contained in Air Force Regulation 80-14 and TAC Regulation 80-1. The test was conducted by the combat crew training wings at Nellis AFB, Nevada and Luke AFB, Arizona.

The following individuals were responsible for the test management and preparation of the final report.

PROJECT OFFICERS	R. G. Reser Major, USAF 4510th CCRTNG WG Luke AFB, Arizona
	Arthur G. Milton MSGT., USAF 4520th CCRTNG WG, Nellis AFB, Nevada
TAC TEST MONITOR	Clifford J. Whitham, Jr. Major, USAF HQ TAC (DORQ-T) Langley AFB, Virginia

TABLE OF CONTENTS

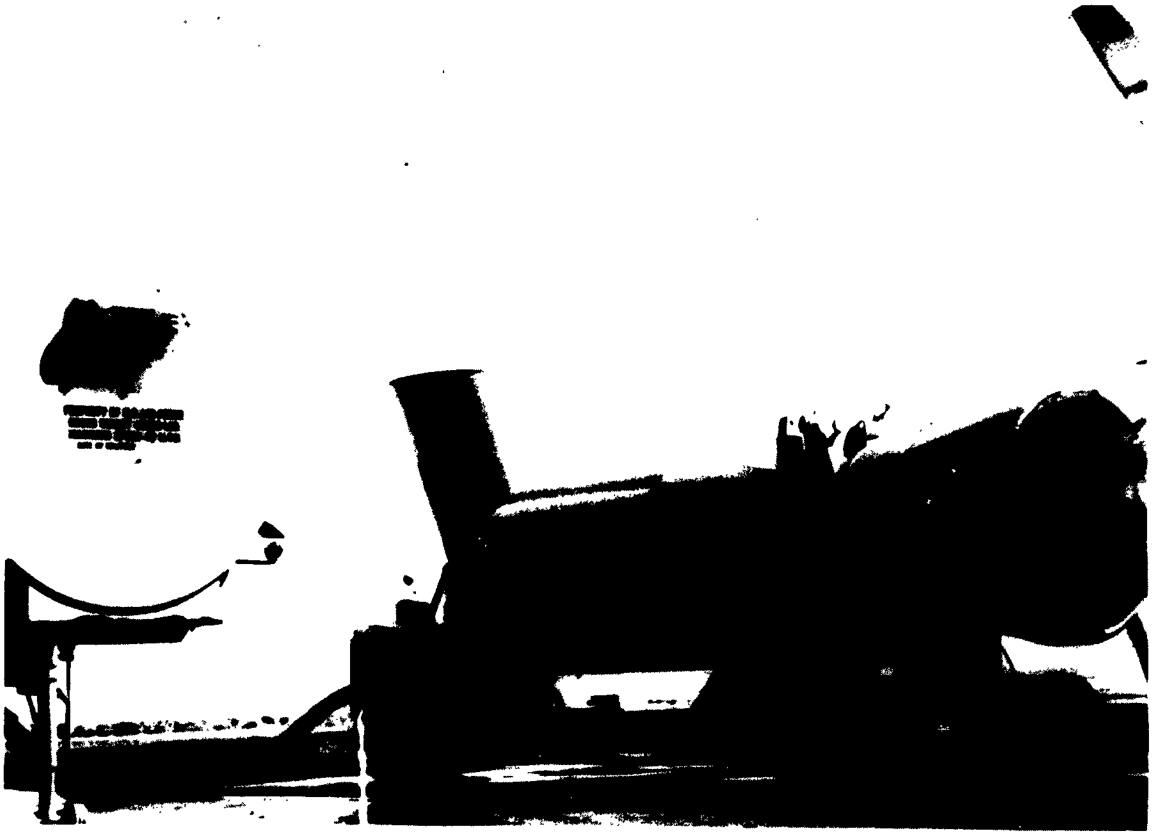

FIGURE 1. Sound Suppressor type A/S32A-5 manufactured by Kittel-Lacy Corp.

1. INTRODUCTION: Since the introduction of turbojet powered aircraft into the Air Force inventory, the intense noise generated during ground maintenance operation of the engines has created problems for the Air Force. It has caused loss of hearing of maintenance personnel and is a nuisance to other base employees as well as the off base population. Only recently has a noise suppression system been developed that appeared feasible for Air Force application. The system tested was selected by ASD as the one that showed the most promise of meeting Air Force requirements.

2. DESCRIPTION: The noise suppressor system consists of an exhaust muffler composed of a sound absorbing shell with a mechanical diffuser, turning vanes mounted inside the shell, and a vertical exhaust duct. An intake muffler is provided which consists of two vertical panels composed of sound absorbing material between a lightweight expanded metal grating on one side and a lightweight steel sheet on the other side. A Packette engine is also mounted on the vehicle frame to drive water and hydraulic pumps. The fluid from the hydraulic pump is used to power a hydraulic motor which drives the front wheels of the vehicle. It is also used to actuate the positioning cylinders. The water pump draws water into the system from a tank mounted on an auxiliary vehicle.

3. PURPOSE OF THE TEST: This test was to determine the suitability of the A/S32A-5 Sound Suppressor, manufactured by Kittel-Lacy, Inc., to reduce the noise of jet engines mounted in test cells and jet aircraft stationed on trim pads.

4. SCOPE OF THE TEST: The following areas were evaluated.

a. The effectiveness of acoustical performance.

b. Ease of mobility and operation of all components.

c. Maintainability.

d. Design (overall and individual components).

e. Adequacy of publications.

5. CONCLUSIONS AND RECOMMENDATIONS

a. Conclusions:

(1) The suppressor did not reduce the engine noise to a tolerable level in the working areas when operating the Pratt and Whitney J75 P19W engine. Sound suppression was noticeable at distances of 100 to 200 feet away from the suppressor at 45 degree angles when testing this type engine. The noise level was reduced to a satisfactory level when using the suppressor on the Pratt and Whitney J57 P21 engine in test cells.

(2) The drive unit is considered adequate for moving the unit for short distances. The number of man-hours required to set up the suppressor for use on the ramp is considered excessive. The method of tie-down is unsatisfactory. If one of the two tie-down chains should break during afterburner operation, the aircraft would probably pivot into the suppressor before the operator could get control. The operating controls were satisfactory but should be centralized on one panel for safer operation.

(3) Units modified with removable internal components could be adequately maintained. No special tools were required to maintain the equipment.

(4) The overall design was unsatisfactory as it did not reduce the engine noise to a satisfactory level with all types of engines. It could not withstand the thrust, shock and tremendous exhaust velocity of the J75 engine. The water sparger, diffuser screen and internal liners were quickly damaged during engine operation. It cannot be properly aligned for use with the F-100 aircraft, resulting in very limited diffuser life. The use of this unit is further complicated by the requirement for water to be used for cooling. Paragraph 10 discusses other deficiencies of this unit in detail.

(5) Technical publications were adequate with the exception of the maintenance technical order. It did not provide sufficient information for the repair of some components.

b. Recommendations:

(1) It is recommended that this unit not be procured for use by the Tactical Air Command. Its procurement cannot be justified in view of the fact that it was found to be unsatisfactory except for use with the J57 engine being tested in test cells.

(2) Research should be continued to develop a mobile, lightweight, air-cooled noise suppressor having high reliability.

6. TEST ENVIRONMENT:

a. The test was conducted at the 4510th Combat Crew Training Wing, Luke AFB, Arizona and the 4520th Combat Crew Training Wing, Nellis AFB, Nevada.

b. Tests were conducted in the engine test cells and trim pad areas at both bases. Only the F-105 aircraft and J75 engine were used in the tests at Nellis AFB. The tests at Luke AFB were confined to the F-100 aircraft and J57 P21 engine.

7. TEST RESULTS AND DISCUSSION - NELLIS AFB, NEVADA

a. The noise suppressor did not reduce the noise level of the J75 engine to an acceptable level of 115 db or less in the immediate work area. A survey was made to determine the sound levels with and without the noise suppressor. All measurements were made with a Hermon Hosmer Scott type 410 Sound Level Meter. The results of this survey are shown in Tables 1 and 2.

TABLE 1. Noise Level Survey - 100 feet from the engine at 45 degree angles

	FRONT OF ENGINE (J75)		REAR OF ENGINE (J75)	
	AFTERBURNER	MILITARY	AFTERBURNER	MILITARY
WITH SUPPRESSOR	97	98	101	101
WITHOUT SUPPRESSOR	122	114	136	132

TABLE 2. Noise Level Survey - ENGINE work area (J75)

	AFTERBURNER	MILITARY	IDLE
WITH SUPPRESSOR	130	130	100
WITHOUT SUPPRESSOR	141	138	104

b. Problems were experienced with the unit as early as March 1962. An inspection of the unit revealed that the internal acoustical liner was distorted and in some areas was deteriorating (see Figure 1 in Annex A). The baffles on the rear of the suppressor were also showing signs of warping. While running a J75 engine, the inner wall acoustical panel started to buckle. It was found that the inner wall had separated and pulled out the wall retaining bolts (see Figure 2 in Annex A). Special jacks were fabricated to support the lining and 37 man-hours were expended welding it back in place. The fillet was welded solid and in such a manner as to prevent overlap facing into the direction of thrust. During another run, the fire guard noted that the water supply to the suppressor was depleted. It was found that the water pump coupling retainer ring had come loose causing the pump to be disconnected from the power source. Figure 3 in Annex A is an illustration of the pump coupling.

c. The rear hydraulic lift was bent due to the vibration of the suppressor when operating engines. The lift was removed and the two front tires were used as shock absorbers to prevent further damage. Figure 4 in Annex A shows the bent hydraulic lift and the effects of the engine vibration.

d. In May 1962, during an engine run of approximately one minute in the afterburner range, the suppressor diffuser screen began to burn and break off. It was found that approximately 3/4 of the diffuser had disintegrated. No further testing was accomplished until repairs were completed in September 1962. The repairs included replacement of the augmenter cone, diffuser, water sparger, augmenter spool and the hydraulic ram. 135 man-hours were required to install these items and accomplish other repairs necessary to return the suppressor to serviceable condition. During an engine run in November 1962, the diffuser screen started to breakup as soon as the engine was put into the afterburner range. It was found that the diffuser screen had almost entirely disintegrated. This was a relatively new screen having only five hours of operating time. Examples of this type of damage are shown in Figures 5 and 6 in Annex A. Figure 7 in Annex A shows parts of the suppressor that were torn from it during an engine run.

e. The suppressor unit does not have sufficient cooling to complete afterburner checks of all components. The engine must be retarded to allow cooling of the suppressor before the afterburner range can be selected again. Despite these precautions, the suppressor is still damaged by the high thrust and temperatures produced by the J75 engine.

8. TEST RESULTS AND DISCUSSION - LUKE AFB, ARIZONA

a. Two noise suppressors were evaluated at Luke AFB. Suppressor #004 was operated 119 hours, 58 minutes and 52 seconds. Total afterburner time on this unit was 9 hours, 31 minutes and 52 seconds. Suppressor #010 was operated 313 hours, 40 minutes and 30 seconds. Afterburner time was 11 hours, 8 minutes and 30 seconds.

b. The pressure switch that operates the red warning light failed on the first run of suppressor #010. As an interim measure, a direct reading water pressure gauge was installed in place of the water pressure switch. The gauge was found to be much more desirable than the warning lights and was later adopted as a formal modification to the suppressor unit.

c. During run #52, the water sparger inner ring broke at the point where the ring was welded to the water tubes, and there were other cracks in the ring. The design of this unit does not permit disassembly and removal of the ring which made repair difficult.

d. The solenoid failed to operate during test run #69. It appeared that the magnetic field in the solenoid was not strong enough to initially pull the solenoid plunger down. Once the plunger was depressed manually, it would hold. There was no evidence of binding and moisture was suspected to have caused the failure. Operation was continued by operating the solenoid manually.

e. The wire mesh screen on the diffuser cone broke at the bottom during run #91. A bow had formed at this point early in the test and had continued to increase as operation continued. Close inspection revealed that eight "hot spots" had formed in the diffuser cone. These "hot spots" aligned perfectly with the cracked recessed areas in the water sparger inner ring between the sparger tubes. It was suspected that the hot exhaust gases generated during afterburner operation were being deflected radially and to the rear from these eight points at an angle of approximately 42 degrees into the diffuser cone wire mesh. The type damage and method of repair is shown in Figure 8 of Annex A.

f. After run #56, several modifications approved by ASD were performed on the suppressor. These included the fabrication of a separate ring, 1/4 inch thick by 2 inches wide, to fit inside the water sparger inner ring. The damage to the diffuser cone was repaired by bolting a circular piece of 3/8 inch thick mild steel boiler plate over the damaged area.

g. During test runs #70, #71, and #72, it was observed that the water flow through the sixteen water spray holes in the water sparger had decreased considerably. During run #72, the water flow ceased entirely, causing the ring to overheat. It was determined that the forward end of the ring had spread radially so that the pressure/velocity of the engine exhaust had overcome the water pressure. Thermal expansion and contraction had caused a small cup to form in the inner ring just forward of the water spray holes at the end of the water tubes. Eight additional 1/4 inch holes were drilled in each of the "cupped" areas to take advantage of the venturi effect just forward of each cup. The effect was excellent and caused the water to be drawn forward over the surface of the inner ring, back over the ring, cooling this area efficiently. After test run #96, another eight 1/4 inch holes were drilled along side the previously drilled holes. The original pair of holes in each of the eight water sparger tubes were plugged. There was no change in water pressure noted after these modifications. Figure 9 in Annex A shows the water sparger removed from the suppressor. The water spray holes drilled in the water sparger can be seen in Figure 10.

h. On 26 February 1962, suppressor #010 was removed from service due to deterioration of the diffuser cone, and a new suppressor #004 was placed in service. No difficulty was experienced with the new unit until run #10 when it was noted that rivets were coming out of the interior acoustic panels and liner. This condition was corrected by welding the panels to the supports. This method of repair was considered a means of checking the condition and not a solution to the problem.

i. Circumferential cracks on five water sparger tubes were noted during run #178 of suppressor #004. The water sparger completely failed during run #183. Five of the water sparger tubes had cracks almost completely through at the welded joints. This point can be seen in Figure 10 of Annex A. This suppressor was removed from service as most of the rivets had come out of the acoustic panels causing them to be too loose for continued operation. The unit had operated 38 hours, 39 minutes and 21 seconds. Afterburner time was 1 hour, 44 minutes and 21 seconds.

j. A new water sparger was received for suppressor #004 in April 1962. Considerable difficulty was encountered in the installation of this part due to misalignment of the holes in the sparger flange. The holes were of the proper size and spacing, but the flange was not properly indexed when it was welded to the water sparger manifold.

k. In April 1962, suppressor #010 had a crack develop in the center of the water sparger between the water tubes. This was repaired by welding a reinforcing ring flush with the rear of the center ring. The acoustic panels on this suppressor also required repair using 64 man-hours. In May 1962, suppressor #004 also had cracks appear on the water sparger ring between the water tubes. These cracks expanded to such an extent that operation was discontinued after run #258. Inspection revealed small cracks in the sides of the acoustical panels. The water sparger ring and acoustical panels were repaired and operation was resumed. Cracks again began forming on the sparger ring and as operation continued, they expanded to such a point that it was necessary to discontinue operation after run #308. Cracks on the water sparger of suppressor #010 caused it to be removed from service after run #102.

l. While moving suppressor #004, a loud "clanking" noise was heard coming from the drive wheels. The cause of the noise was not determined, but later the reverse drive unit would not operate. It was determined that the drive unit had failed and it was replaced in July 1962.

m. Suppressor #010 had an engine failure on 11 August 1962. A loss of RPM and static water pressure were the first indication of failure. After immediate shutdown, an inspection revealed the loss of two quarts of oil and the oil service cap had been forced from the engine. A hole was found in the number three piston after the head was removed. The cause of this failure was not determined as the engine had been properly serviced, maintained and had been operating normally. The engine was removed for repair and the suppressor continued in service using the test cell water supply system. The engine had operated 98 hours at the time of the failure.

n. The wire screen in the diffuser assembly of suppressor #010 began to deteriorate at 190 hours of operation. This unit was being used with the test cell water supply system which has a considerably higher water pressure and flow rate. This provided additional cooling and was believed to have extended the life of this diffuser by 50%.

o. Routine operational maintenance for the suppressor, using the internal engine and water pump, required approximately one man-hour for each operating hour. Approximately .2 man-hour was required for each operating hour when using the test cell water supply system.

p. No accurate sound surveys were made during the test at Luke AFB. Observations indicated the noise level in the immediate work area was reduced to an acceptable level when the suppressor was used with the J57 engine and F-100 aircraft. Comments received from off base residents indicated that the suppressor did produce a noticeable decrease in the jet engine noise level in certain areas.

9. LOGISTIC REQUIREMENTS: These requirements could not be accurately determined during this test due to the continuing modifications and problems experienced with the units. The water sparger could be expected to have a maximum service life of 150 operating hours and the diffuser assembly a maximum of 125 hours. The stainless steel and mild steel water spargers were not in use for a sufficient period of time to determine service life.

10. DEFICIENCIES:

a. Many of the internal components of the suppressor cannot withstand the engine heat and thrust. They must be fabricated from a more substantial heat resistant material.

b. The suppressor does not provide adequate suppression of J75 engine noise.

c. The elevation mechanism's front hydraulic cylinder operates too rapidly, making leveling action critical.

d. At least six more inches of downward movement is required on the rear of the suppressor to permit alignment with the F-100 aircraft.

e. The augmenter cone should be smaller in diameter for test cell use. This would dampen some of the noise that is generated in the suppressor during certain ranges of engine operation.

f. It is necessary to remove the exhaust muffler and two large panels to gain access to the governor and carburetor controls. An access panel with camlock type fasteners should be provided.

g. The oil filler tube should be extended out in a straight line ten inches from the present 45 degree bend to permit oil servicing from any type of can or container.

h. A simple cone-shaped filter should be installed on the inlet side of the water pump to filter out foreign matter larger than the holes in the water sparger.

i. The water drain hole does not provide adequate drainage. It should be enlarged to at least two inches in diameter.

j. For test cell application, the electrical control cable should be 100 feet in length in order to reach the engine control area.

k. The rear hydraulic lift is damaged due to vibration.

l. The internal liners should be welded at the seams instead of using bolts as they vibrate loose.

m. The flare nuts and tubing used in this system are not of standard size. Standard Air Force size number six or 3/8 inch fittings should be used.

n. Safety guards are not provided on the mobility control panel to prevent accidental operation.

o. Caution instructions should be placed on the suppressor at appropriate locations to warn personnel of the extremely high temperature that it retains after use.

p. The operations control panel should have a remote engine control to allow instant stopping of the power unit in the event of an emergency.

q. The tie-down system is unsafe. A single point breakaway system should be provided.

r. The pressure switch (part number 610GB154) was very erratic and should be replaced with a more reliable type.

s. The maintenance technical order does not provide adequate repair instructions on the following parts of the system:

(1) Water sparger.

(2) Interior acoustic panels.

(3) Hydraulic drive system.

(4) Trailer water valve.

(5) Interior acoustic vertical splitter panels in the exhaust stack.

DISTRIBUTION LIST

HQ USAF	
AFORQ-TF	1
AFXOP-TA	1
AFSME	1
AFSSS	1
AFNICAD	1
ASD	
ASNNCP	2
ASWKGF	2
ASZFO	2
AFLC (MCPE)	2
MOAMA (MONSSE)	2
19AF	3
12AF (DMEM-E)	3
9AF (DMEM)	3
4510TH CCrTngWG	
MSFM	2
4520TH CCrTngWG	
MFM	2
SAAMA	
SANRSA	1
SANE	1
17AF (MMEP)	3
3RD AF (DM)	3
ADC (ADMME)	3
SAC (DM4F)	3
PACAF (PFMME)	3
USAFE	
OTS-R	1
MMSE	3
ASTIA (TIS)	1
AU (AUL3T)	1
AGOS (N-8)	1
USAF SAWC	1
USAF TARC (TACT)	1
TAC	
DMEM	2
DORF	1
DMS	2
OA	1
OS	1
LN	4
LAR	2
LM	2
DORQ-T	10

ANNEX A

ILLUSTRATIONS

FIGURE 1. Deteriorated acoustical panel in noise suppressor.

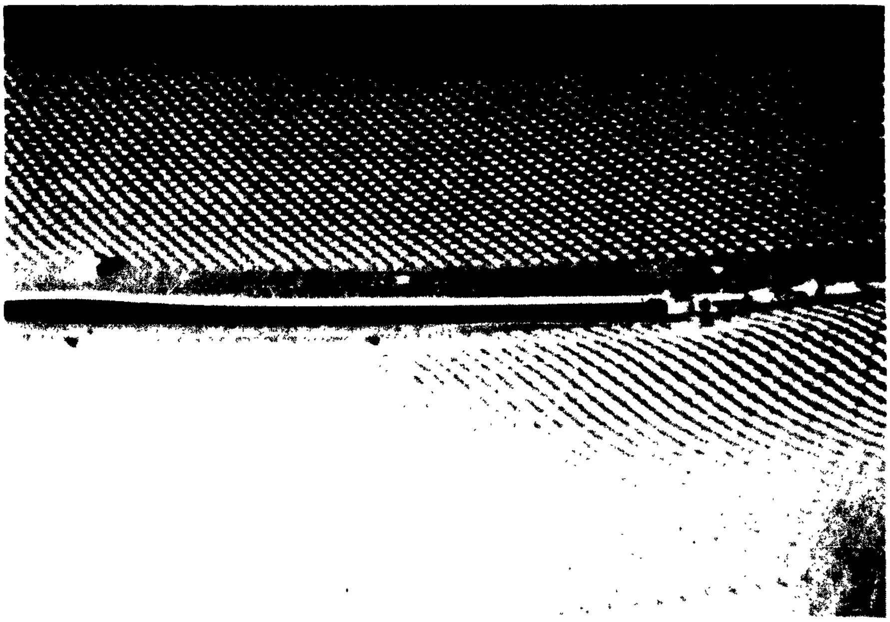

FIGURE 2. Acoustical panel buckled and pulled out retaining bolts. Note welding used to secure panel.

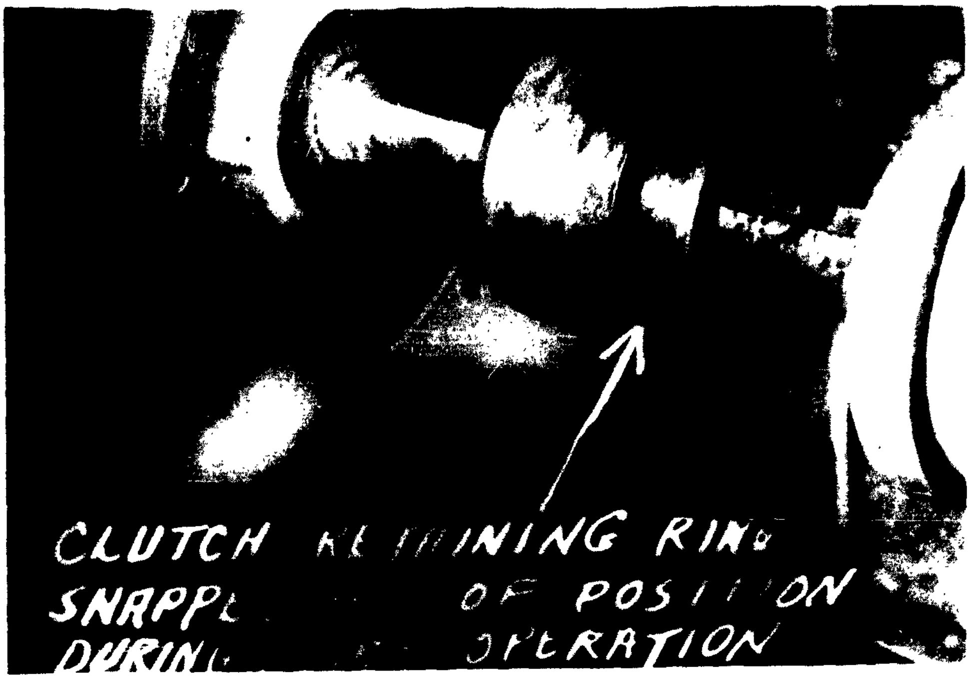

FIGURE 3. Water pump coupling

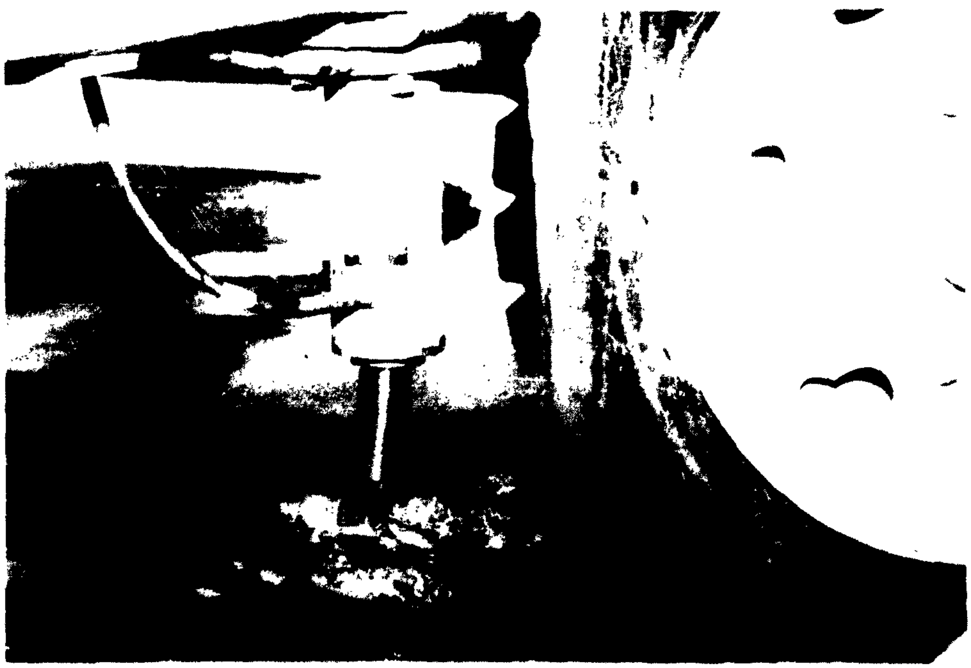

FIGURE 4. Bent hydraulic lift showing force of vibration.

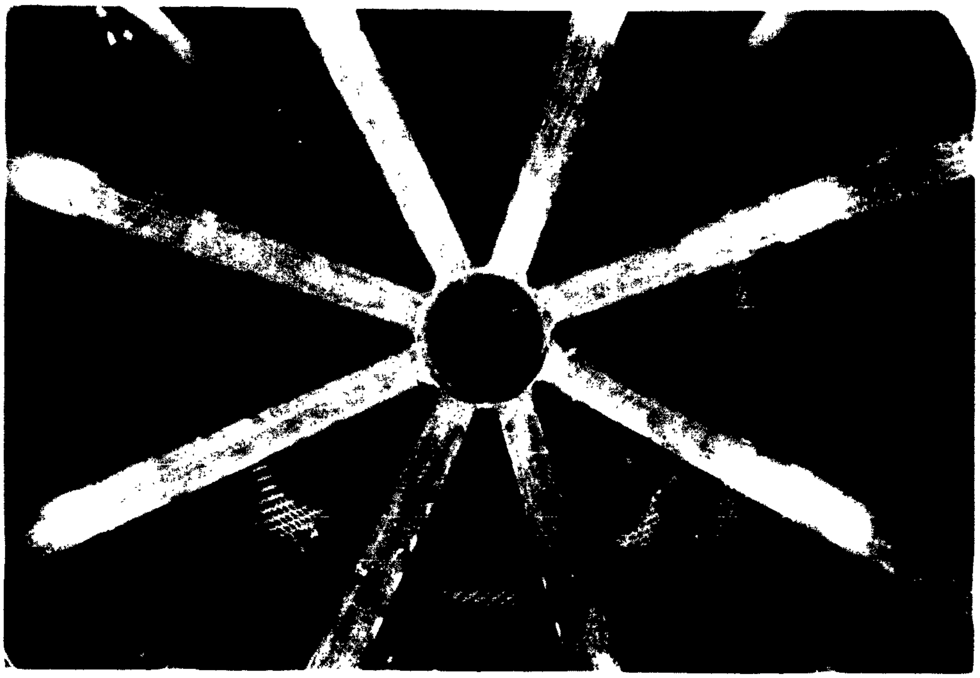

FIGURE 5. Damaged diffuser screen

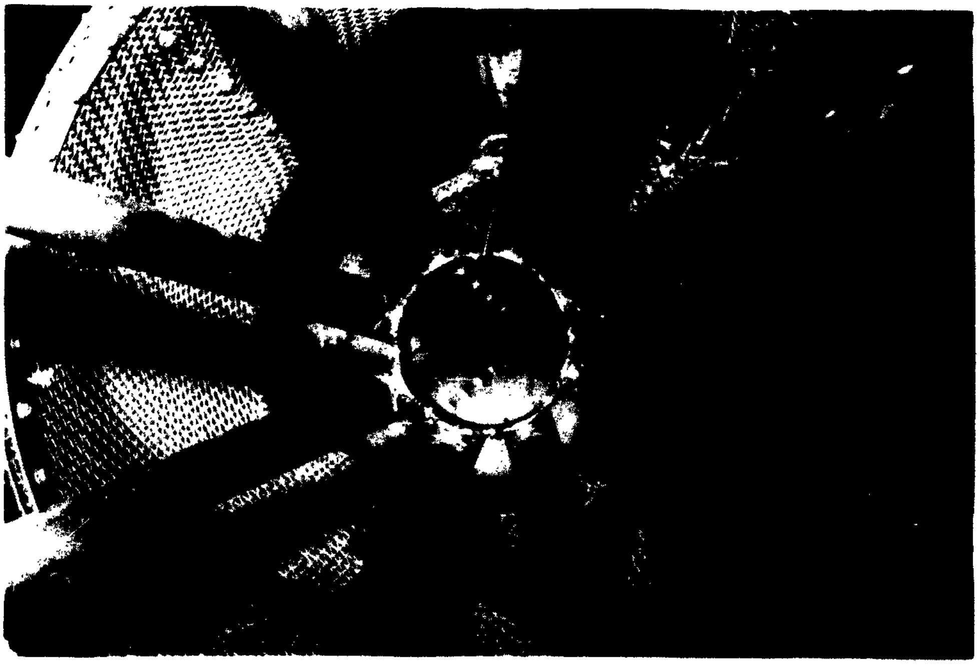

FIGURE 6. Damaged diffuser screen

FIGURE 7. Parts torn from supporessor and ejected during engine run

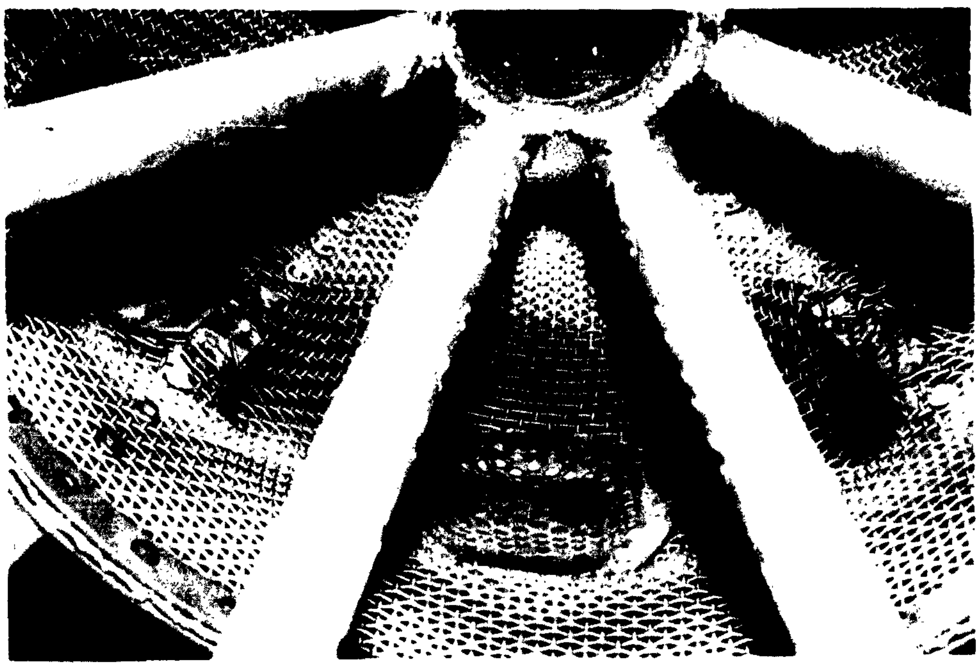

FIGURE 8. Damaged diffuser screen showing method of repair

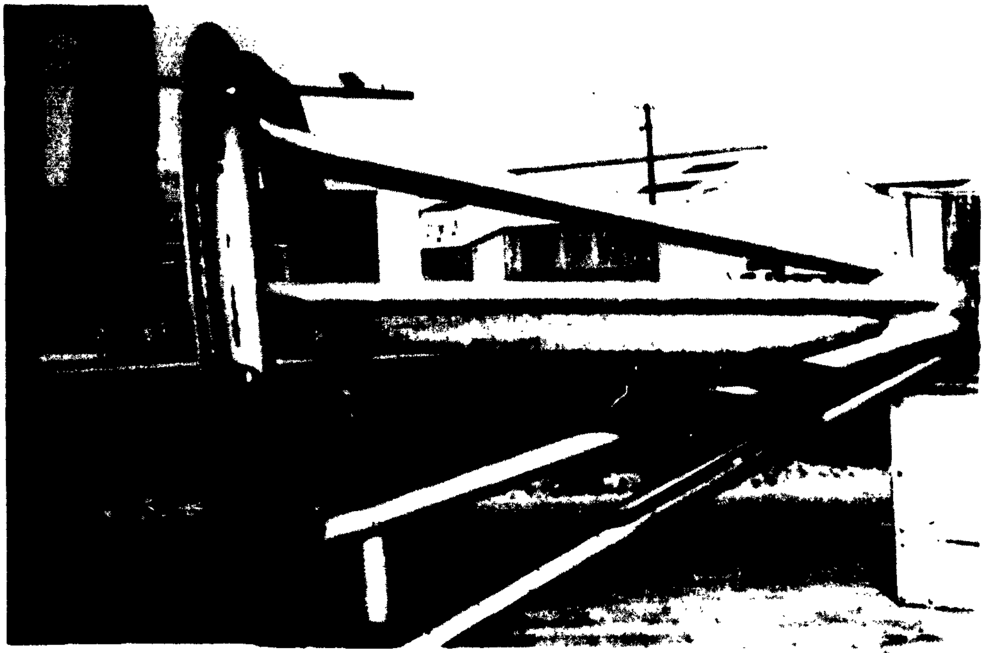

FIGURE 9. Water Sparger.

FIGURE 10. Inner ring of water sparger